OCR
Oxford Cambridge and RSA

GCE

Mathematics

Unit **4728**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2018

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

Annotation in scoris	**Meaning**
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Seen	Confirmation that a page has been reviewed, even though no marking done.
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
D*M1	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
cv()	Candidate's value()
N2L	Newton's Second Law

Subject-specific Marking Instructions for GCE Mathematics (OCR) Mechanics strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper
Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper
Accept any answer that agrees with the correct value to 3 s.f. +/- 1 in the third significant figure.

The degree of accuracy is relevant to the final answer only, as an intermediate "value" need not be evaluated, but could be left as an expression. If an answer is not correct to the required number of significant figures because of earlier premature approximation, it should be regarded as wrong.

There is no penalty for using a wrong value for g. However, answers which are exact using $g = 9.8$ must be correct to 3 sf (or more) when using $g = 9.81$ or $g = 10$. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

'Fresh starts' will not affect an earlier decision about a misread.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer		Mark	Guidance
1	(i)		$6.9 = 0.4 + a \times 2.5$ $a = (6.9–0.4) \div 2.5$ $a = 2.6$ m s^{-1}	**oe** **AG**	M1 A1 [2]	Correct formula with correct values selected
1	(ii)		$AB = (6.9+0.4)\times 2.5 / 2$ *OR* $AB = 0.4x2.5 + 2.6x2.5^2 / 2$ *OR* $6.9^2 = 0.4^2 + 2x2.6AB$ *OR* $AB = 6.9x2.5 – 2.6x2.5^2 / 2$ *HENCE* AB = 9.12(5) m	**oe**	M1 A1 [2]	Candidates may well use a *suvat* formula linking AB and a, as $a = 2.6$ is given in (i) Accept 9.12, 9.125, 9.13 or 9 1/8.
1	(iii)		Distance = $0.4\times0.2+0.5\times2.6\times0.2^2$ Distance = 0.132 m	**oe**	M1 A1 [2]	If two formulae are used appropriately, the M1 mark is given after the second formula has been used correctly. Typically v at 0.2 s (which is 0.92 m s^{-1}) will be seen as an intermediate value. Tolerate 0.13
1	(iv)		distance@2.3 = $0.4\times(2.5–0.2)+0.5\times2.6\times(2.5–0.2)^2 = 7.797$ Distance in final 0.2 s = 9.125 – 7.797 Distance = 1.328 m *OR* Distance = $6.9x0.2 – 0.5x2.6x0.2^2$ Distance = 1.328 m	**oe**	 M1 A1 [2] M1 A1	If two formulae are used appropriately, the M1 mark is given after the second formula has been used correctly. Typically u at 2.3 s (which is 6.38 m s^{-1}) will be seen as an intermediate value. Accept 1.33 m

Question			Answer	Mark	Guidance
2	(i)		Uses cosine rule	M1*	Only acceptable error is the wrong angle (typically 60°)
			$(F+3)^2 = F^2 + 5^2 - 2x5F\cos120$	A1	Accept $(F+3)^2 = F^2 + 5^2 + 2x5F\cos60$
			$6F + 9 = 25+5F$		
			$6F–5F=25–9$	D*M1	Solves for F, includes expanding $(F+3)^2$ correctly. Accept
			$F = 16$ **AG**	A1	explicit verification
			OR	[4]	
			Uses components and Pythagoras	M1*	
			$(F + 5\cos60)^2 + (5\sin60)^2 = (F+3)^2$	A1	Various options, e.g. cmpts // and perp bisector of 60°
			$5F +25/4 +75/4 = 6F + 9$	D*M1	$(F\sin30-5\sin30)^2 + (F\cos30+5\cos30)^2 = (F+3)^2$ Solves for
			$F =16$ **AG**	A1	F, includes expanding $(F+3)^2$ correctly.
	(ii)		Uses cosine rule appropriately	M1*	Need not target bearing angle at this stage
			$5^2 = 16^2 + (16+3)^2 -2x16x(16+3)\cos\theta$	A1	
			$\theta = \cos^{-1} 37/38 = 13.2°$	D*M1	Solves for θ, and applies a step to give bearing, if needed
			Bearing = 013°	A1	Accept 013.2, 13.2
			OR	[4]	
			Uses sine rule appropriately	M1*	Need not target bearing angle at this stage
			$\sin\theta /5 = \sin120 /(16+3)$	A1	
			$\theta = \sin^{-1} 5\sqrt{3} /38 = 13.2°$	D*M1	Solves for θ, and applies a step to give bearing, if needed
			Bearing = 013°	A1	Accept 013.2, 13.2
			OR		
			Uses right angle trig with components appropriately	M1*	May not target bearing angle initially e.g
			$\tan\theta = (5\sin60)/ (16+5\cos60)$	A1	$\cos\alpha = 5\cos30 /19$
			$\theta = \tan^{-1} 5\sqrt{3} /37 = 13.2°$	D*M1	Bearing = $90 –\alpha$ and $\alpha = 76.8$
			Bearing = 013°	A1	Bearing = 90-76.8 = 13.2 = 013
			OR		
			$\sin\theta = 5\sin60/19$, $\cos\theta = (16+5\cos60) /19$ etc		

Question			Answer	Mark	Guidance
3	(i)	(a)	$(0.2g\sin\theta =)\ 1.96\sin\theta$	B1 [1]	Accept $0.2g\sin\theta$
3	(i)	(b)	$Fr = 0.3\text{x}0.2g\cos\theta$ $Fr = 0.588\cos\theta$ *OR* $Fr = 1.96\sin\theta$	M1 A1 [2] M1A1	Accept sin if cos used in (i)(a) Accept $0.06g\cos\theta$ Repeats answer to 3(i)(a) gets M1, and A1 if the answer to 3(i)(a) was correct. Accept $0.2g\sin\theta$.
3	(ii)		$1.96\sin\theta = 0.588\cos\theta$ $\tan\theta = 0.588/\ 1.96$ $\theta = 16.7°$ *OR* $\theta = \tan^{-1}0.3$ $\theta = 16.7°$	M1* D*M1 A1 [3] M1M1 A1	Equates cv (weight component and friction from (i)) or N2L with $a = 0$. Accept use of m instead of 0.2 and μ instead of 0.3 Creates an equation with a single correct trig ratio (numerical values can be incorrect)
3	(iii)		$0.2a = (+/-)(1.96\sin16.7 + 0.588\cos16.7)$ $a = +/-\ 5.632$ $t = 4/\ 5.632$ $t = 0.71(0)$ s	M1 A1 M1 A1 [4]	Both force terms must be components, using cv(θ) and same sign. Value may be implied by later work, sign immaterial. $a = +/-\ 5.5$ to $+/-\ 5.8$ when obtained by correct method and rounded or truncated data. $\lvert a\rvert < g$. $0 = 4 - 5.632t$ is sufficient for M1 with correct signs using cv(θ) and a not a force. 1.42 s is a common wrong answer, usually M0A0M1A0

Question			Answer	Mark	Guidance
4	(i)		Before momentum = 6x0.5 – 2x0.2 6x0.5 – 2x0.2= 3x0.5 + 0.2v v = 5.5 m s^{-1} AB (= 2x5.5 – 2x3) = 5 m	B1 M1 A1 A1 [4]	Must be a difference Uses momentum conservation, one unknown Allow 6x0.5 – 2x0.2= 3x0.5 - 0.2v The above equation gives v = -5.5 for A1 Working based around *suvat* is almost certainly incorrect
4	(ii)		V_B =3 m s^{-1} Before momentum = 6x0.5 – 2m 6x0.5 – 2m = 3x0.5 + 3m (1.5 = 5m) m = 0.3	B1 B1 M1 A1√ A1 [5]	Speed, so must be positive Momentum conservation, 4 non-zero terms of which 2 involve m as the only non-numerical quantity ft cv for V_B if and only if positive

Question			Answer	Mark	Guidance
5	(i)		$0.3a = 0.3g - T$ $0.2a = T - 0.2g$	M1 A1	N2L for individual particle, may be given when finding T Correct equations for both **particles**
			$0.5a = 0.1g$ $a = 1.96$ m s^{-2} $T = 0.2\text{x}9.8 + 0.2\text{x}1.96$ (=2.352)	M1 A1 M1	Tolerate $a = (0.3\text{-}0.2)g/\ (0.3+0.2)$ for this M1 and potentially this A1. Using a value to find T; the initial M1 (for an N2L equation.) could additionally be given at this point
			Force = 2x2.352 Force = 4.7(0) N	M1 A1	Force on pulley is $2T$ used Accept $2T$=4.7(0) for final answer
			SC $a = (0.3g - 0.2g)\ /(0.3+0.2)$ $a = 1.96$ m s^{-2}	[7] M1 A1	Maximum 2 marks for finding a by this illogical method The last 3 marks for finding T and the force by the correct method above may be awarded.
			$0.5g - F = 0.3\text{x}1.96 - 0.2\text{x}1.96$ $F = 4.7(0)$ N	M1 A1	The method for finding F without finding T is unlikely to be seen, but is not totally fortuitously correct.
5	(ii)		Heavier v (= 1.96x1.5) =2.94 m s^{-1}	B1√	Speed of heavier reaching ground, ft cv(accn)x1.5, $\lvert a\rvert < g$.
			Lighter t = 2.94/ 9.8 Lighter continues to move for 0.3 s	M1 A1√	Subsequent free motion under gravity of lighter ft cv(Heavier final speed) /9.8
			Straight line from origin to (1.5, +/-2.94) and no further	B1	CAO. 2.94 strictly between 2.8 and 3.0. Disregard any line from (1.5, +/-2.94) to t axis between t = 1.5 to 1.55.
			Straight line from origin to (1.5, -/+2.94) *AND* Straight line from (1.5, -/+2.94) ending at (1.8, 0)	B1 [5]	CAO. Must be on opposite side of horizontal axis from other particle line. Disregard labelling of lines (heavier, *P*, *A* etc.)

Question			Answer	Mark	Guidance
6	(i)		$x = \int 2+t^2\ dt$ $x = 2t + t^3/3\ (+c)$ $x\ (=2x3+3^3/3) = 15$	M1 A1 A1 [3]	Integration used and displayed by increase in power and change in coefficient of t^2 c may be ignored or stated =0 $15+c$ is A0, unless $c = 0$ stated
6	(ii)		$(v = dx/dt =)\ b + 4ct^3$ $(a = dv/dt =)\ 4x3ct^2$ $(a = dv/dt =)\ 2t$ $2x3 = 4x3c3^2$ $(6 = 108c)$ $c = 1/18$ **AG**	B1 B1 B1 M1 A1 [5]	"Later" formula "Later" formula "Earlier" formula Equates expressions for accn when t =3
6	(iii)		$x(3) = 2x3 + 3^3/3\ (= 15) = a + 3b + 3^4/18$ $v(3) = 2+3^2\ (=11) = b +4x1/18\ x3^3$ $b = 5$ $x(3) = 15 = a + 5x3 + 3^4/18$ $a = -4.5$	M1 M1 A1 A1 [4]	Equates expressions for x when t =3. Tolerate candidates use of own incorrect value of c. Equates expressions for v when t =3 Tolerate candidates use of own incorrect value of c. Substituting b into $x(3)$ expression Accept -9/2.
6	(iv)		$25 = 5+4xt^3/18$ $t\ (=\sqrt[3]{90}) = 4.48$	M1 A1 [2]	Uses formula for v for "later" motion with their value of b. This A1 is not awarded if solution, also includes t = 4.79.. from using the formula for v in the first 3 s, unless it is rejected.

Question			Answer	Mark	Guidance
7			1250sin5, 150sin5, 1400sin5, *Wg*sin5		These terms are not accurate expressions for weight components. However, they may be used in any part of a candidate's answer as a weight component, FOR M AND DM MARKS ONLY
7	(i)	(a)	(1250+150)*a* =	M1	Car + Trailer N2L equation with correct total mass and at least one force relating to each (accept missing *g*)
			1800 – 350 - 80 - 1250*g*sin5 – 150*g*sin5	A2	-1 for each incorrect or missing term to zero
			$a = 0.124$ m s^{-2}	A1	
			OR	[4]	
				M1	N2L for car mass 1250 *OR* trailer mass 150 must include *T* (accept missing *g*)
			1250*a* = 1800-350-*T* -1250*g*sin5	A1	
			150*a* = *T* - 80 – 150*g*sin5	A1	
			$a = 0.124$ m s^{-2}	A1	n.b. No M mark for solving 2 Simultaneous Equations
7	(i)	(b)	Motion of trailer	M1	N2L, correct number of terms including *T*, weight compt, allow 150sin5
			150 x 0.124 = *T* – 80 -150*g*sin5	A1√	ft cv(accn)
			T = 227 N	A1	
			OR	[3]	
			Motion of car	M1	N2L, correct number of terms including *T*, weight cmpt, allow 1250sin5
			1250 x 0.124 = 1800 – 350 – *T* - 1250*g*sin5	A1√	ft cv(accn)
			T = 227 N	A1	

Question			Answer	Mark	Guidance
7	(ii)		0		This can be accepted from 1250*g* x 0
			= 1800 – 350 - 1250*g*sin5	M1*	Reduce tractive force by resistance and weight component of car, acceleration zero. Allow 1250sin5.
			- *W*sin5 -150*g*sin5	D*M1	Includes weight cmpt of trailer + load (accept *Wg*sin5 and/or 150sin5)
			– 0.05*W* – 80	D*M1	Includes motion resistance of trailer + load (accept 0.05*Wg*)
			W = 1270 N	A1	
			OR	[4]	
			0 = 1800 -1250*g*sin5 -350-*T*	M1*	Finds tension in tow bar when car has zero accn. Allow 1250sin5
			T = 382.34..		
			0 = 382.34 - 80 - 150*g*sin5 - *W*sin5 – 0.05*W*	D*M2	Balances tension against trailer resistances to motion, -1 error to zero. (accept *Wg*sin5 and/or 150sin5 and/or 0.05*Wg*)
			W = 1270 N	A1	

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